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Fauna of bats as an indicator of the most valuable natural complexes in Chernobyl exclusion zone worthy of legislative protection

Final Report

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Final report of RSG project: "Fauna of bats as an indicator of the most valuable natural complexes in Chernobyl exclusion zone worthy of legislative protection"

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Introduction

The accident at the Chornobyl NPP in April 1986 occurred to be the most severe man-caused catastrophe in the history of mankind. A lot of radioactive substances were released into the environment, widely spread in the world; however the largest amount fell out within a radius of 30-50 km around the plant. Extremely high radiation doses forced people to leave these lands for an indefinitely long period. Over 135 thousand people were evacuated from about 70 settlements. Dozens of thousands of livestock were evacuated; all types of economic activities were stopped; buildings, enterprises, equipment and communications were abandoned. Ecological systems, which have been subject to anthropogenic transformations during hundreds of years and were, to a great extent, artificial ones, were cut off the maintenance and left face to face with spontaneous natural power. Approximately 6,000 km2 of lands in Ukraine, Belarus, and Russia were abandoned by people in a clap. Pursuant to the states' decisions, exclusion zones and depopulated areas were established there. Adjacent to ChNPP radioactive territories of Belarus were announced as a Polessky State Radiation Ecological Reserve (2,150 km2) already in 1988; its mission is to ensure environmental and research activities. In Ukraine, the Chornobyl Exclusion Zone (hereinafter – ChEZ) was established. Currently, ChEZ has an area of 2,600 km2. Major lines of activities within ChEZ were: comprehensive support to the processes of stabilizing and improving radiation and ecological situations within the affected areas, prevention of radioactivity carry-over outside the region, and minimization of the accident consequences. The Law of Ukraine established a special form of governance there; the lands were classified as radioactively hazardous ones, taken out of economic circulation, and separated from the surrounding territories. They are enclosed along the perimeter and equipped with checkpoints; stay and all types of activities within ChEZ are subject to strict regulation and control. Though industrial enterprises and watch personnel have been continuously present within ChEZ, their activity impacted only 5-10% of the total area. Meanwhile, total cessation of economic activities has triggered natural development processes in the ecosystems. Reservation conditions de-facto exists in 90% of the territory (i.e. over 2,200 km2), gradual restoration of autochthonous biological systems is currently in process.

Expert assessments state that flora and fauna have also achieved a considerable diversity and abundance which have not been registered there for centuries. In particular, over 320 species of only vertebrate animals out of 410 possible ones were noted there, and 55 species (out of 97 possible) are on the "red list" of Ukraine. Over 1500 species of lichens, mosses, and higher plants were registered there; many of them are also red-listed, regionally endemic or relict. Lack of agricultural and forestry activities contributed to the invertebrate fauna recovery, the system of pollinating insects was enriched. The local biological diversity is presented by 23 terrestrial and 7 aquatic phyto-systems, 12 terrestrial and 8 aquatic zoo-systems, 5 types of landscapes and up to 15 types of soils. The population of ungulates, carnivores, and other game species increased and came up to the highest level possible at this local biocenoses development stage. The lynx, otter, and beaver populations increased during the last 25 years. Despite a high number of wolves, the density and abundance of elk is the highest in Ukraine, the red deer, wild boar, and roe deer populations have also increased considerably. The white-tailed eagle, spotted eagle, black stork, gray crane, eagle owl, and many other rare birds are rather common. ChEZ is located at the intersection of main routes for bird seasonal migration.

13 objects of the nature reserve fund were established within the region prior to the ChNPP accident; however, they covered less than 1% of the total area and had a low protection status. Another object was added in 2007 and thus enlarged the total area of conservation area up to 20%. However, these natural sites have now a low protection category and an environmental institution is absent. Meanwhile, the previous and current steps of the state in this regard demonstrate recognition of the region's value as a wildlife reserve.

The current ChEZ together with the Polessky State Radiation Ecological Reserve in Belarus form a single natural and geographical system with the total area of 4,750 km2. The "Drevlyansky" Nature Reserve (30,873 ha) was also recently established (2008) in the adjoining territory of the

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Zhytomir region of Ukraine. These existing areas can therefore now be considered as the basis for potentially vast Protected Area Network with a combined core area of over 5,000km2. Its size and landscape diversity ensure recovery of sustainable relations and flows in biocenoses, being impossible within smaller areas. Potential of this vast territory provides for independent reproduction and support of not only small and sensitive to anthropogenic impact species, but also of the species that require spacious individual sites. Just that very fact is confirmed by occurrence and regular registration of the brown bear that has disappeared during the last century, as well as by a successful increase of the European bison population in the neighbouring Belarusian territory.

All these changes and circumstances are favourable as far as ChEZ mission is concerned. It was recognized that ecosystems constitute the most appropriate, efficient, and safe barrier preventing spread of radioactivity. Supporting their safe state guarantees safety within the neighbouring areas. Moreover, the priority is given to exactly natural ways. Interference is involved only under the threat of a significant radionuclides carry-over (floods, fires). Such an approach does not contradict the ideas and directions of environmental activities, therefore the latter has prospects for further development within the ChEZ.

Since over 25 years generic radioecological situation in ChEZ became much softer ways of further management of abandoned lands are intensively discussed. The idea of establishment of nature protected areas of high category is one of the most reasonable, and also taken into consideration. However realization of this idea has some formal obstacles. One of them is lack or absence of detailed description of biological complexes for every location of this huge area. It is clear that whole territory of ChEZ cannot be announced as a natural reserve, since besides some areas where specific industrial activities take place there are vast wild lands which also have different quality and value in nature conservation concern. Thus necessity and definition of the protection categories is in dependence on initial information which can indicate it. We see that information of bats population can help in this respect. All species of the bats are under protection in Ukraine (regardless their real abundance). They are fastidious animals as need rich choice of appropriate roosts on vast area (most of local species are tree-dwelling), and rich choice of hunting habitats. In fact they prefer such habitats (mature forests untreated by forestry activity, swamped forest, water objects, abandoned settlements) which are favourable for plenty other endangered species (owls, black stork, crane, spotted and white-tailed eagles, some waterfowl species, insects-xylophagous, lynx, otter, etc.). Therefore diversity and abundance of bats can reflect not only importance of the given habitats for their population, but as well can indirectly indicate value of the land in biodiversity and nature conservation concern.

By the RSG project beginning there were preliminary data of the local bats collected by the executers of the project during previous 6 years (mostly field data, there are very few published data for this region).

The project aim

The aim of the project was to justify urgent necessity to reserve some natural complexes in the ChEZ as key habitats of number endangered and rare animals. On the base of results of bat fauna survey proposals of the lands conservation and protection will be elaborated. Obtained information will be spread among governmental and non-governmental organisations, public communities, scientific and conservation societies in order to form overall opinion that the Chernobyl land is worth to be protected as very valuable natural complex playing important role in maintaining all-Europe biodiversity.

Study approaches, methodology and schedule

Taking into account huge size of the ChEZ territory the main efforts were spent for successive investigations the most promising Chernobyl lands: mature deciduous and mixed forests, near lakes, rivers and marshes, both where the rare species had been recorded before (to check again), and in new ones. In fact this project was as a logical continuation and development of the previous similar studies. The results obtained both give grounds to judge about nature value of the given study site and provide tips for search and preliminary assessment of next areas.

The main study method was catching bats by mist nets (3x12 m, 15 mm mesh, 8 pockets) installed on telescopic poles. As usual one mist-net per site was installed in the most favourable place: bridge over river, bank of lake (river), sometimes above the water, cross the flying pass in forest, etc. In rare cases where we were not confident in correctness of the net position (or desired to overlap a wide fly-pass) two mist-nets were set at one site. Duration of the mist-netting as usual ranged from 6.0 to 8.0 hours (average 6.7 hours): since sunset and almost until sunrise, however sometimes the capturing was shorter (3-5 hours) because of different reasons (strong wind, rain, etc.).

As usual we did not undertake preliminary search of the bats concentration using ultrasonic detector. However the detector (Pettersson D200 and D240x) was commonly used over the night to control animal activity and to take records for further identification of species (by BatSound 4.03, Pettersson Elektronik AB). We used the vocalization records only for preliminary generic imaginations about the bats fauna (abundance, activity, spatial distribution, main species or "sound groups"). Our study summaries and conclusions are derived mostly from the results of the mist-netting.

In all expeditions five-six persons participated therefore we had an opportunity to set the nets in up to 3 sites simultaneously on distance at least 200 m from each other. The next night we changed sites. All sites were chosen in radius 1.5-2 km maximum around the field camp. In 2010 we undertook repeated survey at the same sites during two weeks (following the method of bat fauna inventory - *Vlaschenko, A. S. and Gukasova, A. S. 2009. Development of method for the inventory of species composition and population structure of bats. Nature reserves in Ukraine 15 (1): 49–57*). For every site coordinates were recorded.

The captured bats were put into fabric bag (separately for every species and no more 10 individuals per bag), and hung on the pole. In own turn they attracted flying bats and increased efficiency of the mist-netting.

In those cases when we found roosts in tree-holes, a specific tree-hole trap (*Vlaschenko A.S. A plastic trap for capturing dendrophilous bat species. Plecotus et al. 2004. 7:3-6 (in Russian)*) was used to get the bats. In 2011 we used borescope DCS400 for preliminary investigation of the holes

During a day after the capturing all the bats were processed: definition of species, gender, age, reproductive state, and measurement of body mass and forearm length. All bats were banded with an individual chiropterological rings (Aranea, Poland). All measures related to bat capturing, holding and carrying in bags were ethical, respectful for animal welfare and conservation of protected species, according to Gannon (*Gannon, W. L. 2007. Sikes and the animal care and use committee of the American Society of Mammalogists. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 88 (3): 809–823*).

The next night all bats were loosed soon after sunset. Sometimes we loosed the animals earlier, placed them in attic of abandoned buildings, in cracks of the roof cover.

Simultaneously with the mist-netting we investigated habitats around collecting information about woods composition, age and state of the wood stands, presence (or absence) of water objects, swamped lands, abandoned settlements or other human constructions. We recorded all findings of rare species of animals and plants. Level of the present anthropogenic impact on nature was also assessed. Radiological issues were not taken into consideration, since on current stage it does not influence on choice and preference of habitats by bats, and on biodiversity there. However elaborating justification for establishment of the protected areas we will use all available radiological data for detailed description of these lands.

In the beginning of the project it was supposed to study bats since the third decade of May to the first decade of August (2010-2011), with certain break in June when maternal colonies are the most sensitive to extra disturbance. Three-week expeditions in May-June and July-August were desired and some short investigations (2-4 days) in other periods as well. However since all participants of the project do have other individual duties and obligations in their job (education) organizations, the allocation of time for the bat studies in Chernobyl became a really challenging task. Additional trouble was regularly caused by absence of car appropriate for hard-to reach areas. That is why in fact we fulfilled only three large expeditions (19 days, 11 days and 14 days) and several preliminary surveys with the bat-detector or scout trips of new locations.

After the finish of the field work we planned to process the results obtained. In fact, it coincides with the finish of the RSG project period, which is why not all output information are possible to represent now. It (will) include(s): 1) knowledge of population state and distribution of bat species (including Red List ones) as well as of other animals within the ChEZ, 2) knowledge and detailed description of the most valuable habitats and lands there. On the base of these data we will provide: 1) grounds to elaborate proposals for gradual development of nature conservation activity in the ChEZ, and to demand corresponding steps of the Authority, 2) information for public distribution and enlightenment, for popularization of the idea to create Chernobyl nature reserves via presentations, articles, interviews, websites. The project will allow to strengthen the previous scientific relationships, and to set new contacts, first of all, with conservationists. The project implementation will be great practice for the graduate students. Altogether it will lay a base for future nature conservation and research activity in the ChEZ.

Main project results

During project period (and at RSGF support) we carried out three large expeditions (Table 1). Total duration 44 days of field works, we caught the bats at 56 sites of 9 locations within the ChEZ (Table 2, Fig. 1). Due to these efforts total number of sites where bats studies took place increased up to 120, which cover total area up to 500 km2.

Total number of “net-nights” – 89, including 59 successful (at least one animal was caught). Number of animals per net-night ranged from 0 up to 119, with average 10.8.

Over the project period we caught 11 species, including two ones recorded the first time: *Barbastella barbastellus* and *Myotis brandtii*. A single and very old information about finding the Barbastelle bat in this region was in 1950s, while *Myotis brandtii* has been not recorded ever in radius of at least 250 km.

Total number of species recorded in the Chernobyl zone reached 14 (Table 3). Among two possible sibling species – *Pipistrellus pipistrellus* and *P. pygmaeus* – only the later was recorded on the base of vocalization (55 kHz). There are still no reliable evidences (genetic, vocal, morphological) of presence of *P. pipistrellus*.

Table 1. Brief description of RSG-project content.

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No	Terms (duration)	Participants	Locations investigated (ID), number of sites
1	15.07.10 – 02.08.10 (19d)	Gashchak Sergij (PI) Vlaschenko Anton[1] Elagina Dasha[2] Sudkova Masha[3] Nagorny Eugenie[4]	1. Yakovetskoye Forestry (Y), n= 13; 2. "Gorodische"(G), n=7.
2	22.05.11 – 01.06.11 (11 d)	Gashchak Sergij (PI) Vlaschenko Anton[1] Sudkova Masha[3] Kravchenko Ksenya[5] Biatov Anton[6]	1. Yampol (Ya), n=2; 2. Andreevka (An), n=2; 3. Belaya Soroka (BS); n=10 4. Novosyolki (N), n=7.
3	20.07.11 – 02.08.11 (14d)	Gashchak Sergij (PI) Vlaschenko Anton[1] Nagorny Eugenie[4] Kravchenko Ksenya[5] Naglov Aleksandr[7]	1. Gorodchan (Go), n=5; 2. Zimovischa (Z), n=3; 3. Belaya Soroka (BS), n=7; 4. Vilcha (V), n=7.

Note. The project participants:
[1] Researcher, PhD, Interdepartmental Research Laboratory for the study of Biodiversity and Nature Reserve Development (Kharkov, Ukraine);
[2]MD Student, Karazin Kharkov National University (Kharkov, Ukraine);
[3]MD Student, Karazin Kharkov National University (Kharkov, Ukraine);
[4] MD Student, Karazin Kharkov National University (Kharkov, Ukraine);
[5] MD Student, Karazin Kharkov National University (Kharkov, Ukraine);
[6] Researcher, National Nature Park "Gomolshanskie lessy" (Korobov Khutor, Ukraine);
[7] Researcher, Associate professor, PhD, Karazin Kharkov National University (Kharkov, Ukraine).

Table 2. Project locations and sites, volume of work and total results.

ID of the site	Longitude*	Latitude*	Net-night	Number of animals	List of species
"Gorodische"					
G1	29.926710	51.394620	1	21	N.leis., N.noct.
G2	29.865010	51.397620	2	28	B.barb., N.leis., N.noct., P.pygm., Pl.aur., V.mur.
G3	29.884790	51.397610	1	59	M.daub., N.leis., N.noct., V.mur.
G4	29.870740	51.397720	1	13	M.daub., N.noct., P.pygm., Pl.aur.
G5	29.875600	51.405600	1	16	N.leis.
G6	29.870050	51.404000	1	87	M.daub., N.leis., N.noct., P.pygm., Pl.aur., V.mur.
G7	29.857148	51.421955	1	31	Ep.ser., N.leis., N.noct., P.nath., Pl.aur.
Andreevka					
AN 1	30.085480	51.152310	2	6	N.leis., N.noct., V.mur.
AN 2	30.084720	51.151630	1	1	P.pygm.
Bela Soroka					
BS1	29.921660	51.486300	2	11	N.leis., N.noct.
BS2	29.946450	51.483410	1	3	M.das., P.nath., P.pygm.
BS3	29.945249	51.478807	4	11	M.das., M.daub., N.noct., P.nath., P.pygm.
BS4	29.933150	51.473120	1	0	
BS5	29.934950	51.476050	1	0	
BS6	29.933600	51.488560	2	1	M.daub.
BS7	29.938500	51.484510	2	3	N.noct., P.pygm.

BS8	29.935370	51.476520	1	2	P.nath
BS9	29.937240	51.487160	1	0	
BS10	29.935940	51.486880	2	0	
BS11	29.932900	51.478850	1	3	P.pygm
BS12	29.923820	51.478190	1	11	N.leis., N.noct., P.nath., P.pygm.
Vilcha					
V1	29.450580	51.356620	1	3	P.pygm., Pl.aur.
V2	29.464010	51.346940	2	21	N.leis., N.noct., P.nath., P.pygm.
V3	29.465920	51.346700	1	8	N.leis., N.noct., P.pygm., V.mur.
V4	29.466470	51.346560	1	0	
V5	29.460178	51.359189	1	3	M.brand., N.noct.
V6	29.450010	51.358910	1	28	Ep.ser., N.leis., N.noct., P.pygm., V.mur
V7	29.450430	51.357150	1	29	M.daub., N.leis., N.noct., P.nath., P.pygm., Pl.aur., V.mur.
Gorodchan					
Go1	30.276890	51.459270	1	0	
Go2	30.268200	51.459710	1	17	N.leis., N.noct., P.nath., Pl.aur.
Go3	30.273310	51.460920	1	2	M.daub., N.noct.
Go4	30.279700	51.464080	1	0	
Go5	30.228490	51.471930	1	24	N.leis., N.noct., P.nath., Pl.aur.
Zimovische					
Z1	30.169680	51.420150	2	8	N.noct., P.nath., P.pygm.
Z2	30.194020	51.423340	1	25	P.nath., P.pygm., V.mur.
Z3	30.193420	51.422700	1	37	M.das., N.noct., P.nath., P.pygm., V.mur.
Novosyolki					
N1	30.020090	51.205050	2	26	M.daub., N.leis., N.noct., P.nath., P.pygm., V.mur.
N2	30.020030	51.210370	1	0	
N3	30.018790	51.214810	1	1	P.pygm
N4	29.995390	51.223760	1	1	P.nath.
N5	30.002970	51.224460	1	4	N.noct., Pl.aur.
N6	30.003770	51.223550	1	0	
N7	30.002050	51.210840	1	0	
Yakovetskoye Forestry					
Y2	29.609136	51.398557	2	0	
Y3	29.627760	51.388080	2	3	N.leis., V.mur.
Y4	29.617430	51.387850	2	19	N.leis., N.noct., Pl.aur.
Y5	29.624730	51.382070	2	28	N.leis., N.noct., Pl.aur., V.mur.
Y6	29.597950	51.389530	2	10	N.leis., N.noct., Pl.aur., V.mur.
Y7	29.602411	51.376208	2	65	Ep.ser., N.leis., N.noct., Pl.aur., V.mur.
Y8	29.615500	51.394740	2	164	Ep.ser., N.leis., N.noct., P.nath., P.pygm., Pl.aur., V.mur.
Y9	29.581860	51.379300	2	0	
Y10	29.625703	51.371823	2	145	N.leis., N.noct., P.nath., P.pygm., V.mur.
Y12	29.627370	51.390090	1	29	N.noct
Yampol					
Ya1	30.194010	51.220710	1	0	
Ya2	30.202650	51.224050	2	0	

*Coordinates: Longitude/latitude, degrees, WGS8

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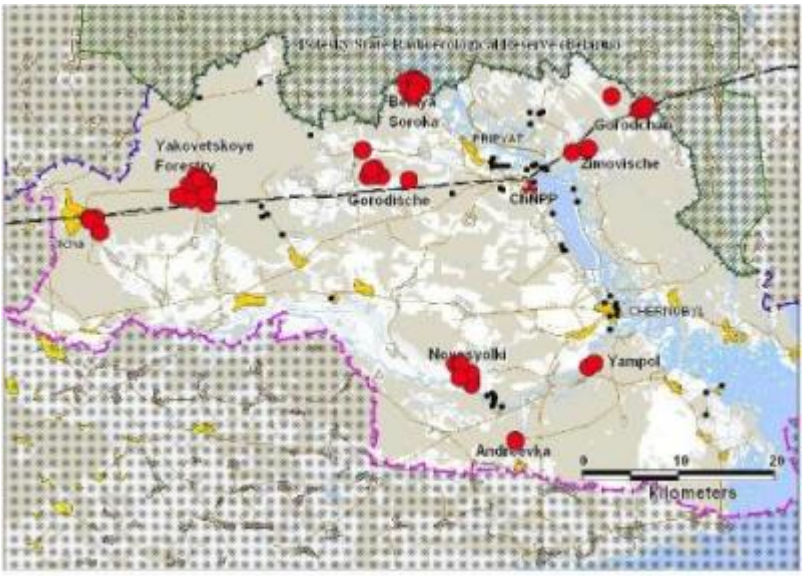

Fig. 1. Distribution of RSG-project locations and sites (red dot) within ChEZ in 2010-2011. Black dots – sites investigated in 2004-2009 (Hereafter on the figures grey colour means woodlands, white – meadows, reddish – settlements with few human population).

Table 3. Total number of bats caught in the Chernobyl zone over total period of the studies, and including the RSG project (in the brackets – including recaptured animals).

Species	2004-2011 (total period of bat studies in region)	2010-2011 (including the RSG project)
1. Barbastella barbastellus	1	1
2. Eptesicus serotinus	57	4
3. Myotis brandtii	1	1
4. Myotis dasycneme	4 (1)	3 (1)
5. Myotis daubentonii	32	15
6. Myotis mistacinus	1	
7. Nyctalus lasiopterus	1	
8. Nyctalus leisleri	272 (2)	143 (2)
9. Nyctalus noctula	991 (28)	631 (25)
10. Pipistrellus kuhlii	11	
11. Pipistrellus nathusii	475 (3)	46
*12. Pipistrellus pygmaeus**	313	50
13. Plecotus auritus	62	29
14. Vespertilio murinus	140	86
Total	2361 (34)	1009 (28)

*Note: *Pipistrellus pygmaeus* is still considered as only representative of *Pipistrellus pipistrellus* s.l. in the region, basing on vocalization characteristics (55 kHz)

Most of species studied are represented both by adult females and males, although there are certain predominance of females (Table 4). In 11 of 14 species immature (sub adult) individuals were recorded in July-August that means that most of the species breed on this territory.

Table 4. Gender and age composition (%) of bats caught in the ChEZ in 2004-2011*

Species	May-June			July-August					
	Adult			Adult			Immature		
	f	m	N	f	m	N	f	m	N
Barbastella barbastellus							100.0	0.0	1
Eptesicus serotinus	47.1	52.9	17	26.9	73.1	26	38.5	61.5	13
Myotis brandtii									
Myotis dasycneme	0.0	100.0	2	0.0	100.0	2			
Myotis daubentonii	50.0	50.0	14	23.5	76.5	17	0.0	100.0	1
Myotis mistacinus				0.0	100.0	1			
Nyctalus lasiopterus							0.0	100.0	1
Nyctalus leisleri	91.7	8.3	48	88.4	11.6	43	46.4	53.6	179
Nyctalus noctula	66.7	33.3	78	87.1	12.9	201	52.6	47.4	709
Pipistrellus kuhlii	71.4	28.6	7						
Pipistrellus nathusii	55.0	45.0	140	64.7	35.3	136	51.8	48.2	195
*Pipistrellus pygmaeus**	100.0	0.0	52	96.0	4.0	25	56.4	43.6	227
Plecotus auritus	83.9	16.7	24	63.0	37.0	27	62.5	37.5	8
Vespertilio murinus	89.5	10.5	19	82.4	17.6	17	58.0	42.0	100

*Note: f – female, m – male, N – total number of animals investigated

We caught bats not everywhere and not always at the same site. Season and weather conditions influenced on efficiency of the mist-netting very much. July-August is a more fruitful season than May. Cold night at clear sky (min temperature less +10°C), strong wind and rain were not favourable for the bats activity and the mist-netting. Not all species which undoubtedly were at the site (according to ultrasonic detection and visual observations) got into the net. For example, *Nyctalus noctula*, the most common and abundant species, not always was caught but always was heard. Often visually observed *Plecotus auritus* find out the mist nets very easy and avoid capturing. Installation of the mist nets on bank of lake or river can decrease probability to catch *Myotis daubentonii* in comparison with installation directly above the water. That is why the absence of some species in captures at certain locations does not mean the absence in those habitats.

We recorded totally near 200 minutes of the bats vocalization at the study sites. However so far we are not ready to use these data to state about presence of different species because of lack of experience to distinguish them. Nevertheless these records are very useful to judge about possibility of some species (or a group of the species) and total abundance and activity of the animals. In future after additional mastering these records hopefully will be also used for identification of the species.

Considering the total sample of bats caught over all years of investigations (2004-2011) four main groups of species inhabiting ChEZ can be distinguished. The first – species-dominants and subdominants (*N.noctula*, *N.leisleri*, *P.nathusii*, *P.pygmaeus*, *V.murinus*, *P.auritus*) (Table 5). They were caught in 15-21 of 26 locations. Evidently distribution of *P.auritus* is limited by woodlands and settlements with well-developed wood vegetations (at least not very far from it), while other species are common above meadows, large rivers, lakes and swamps as well. The second group - common and somewhere abundant species, however they have very irregular pattern of distribution: *E.serotinus* is associated with urban landscape, *M. daubentonii* – with large lakes and rivers. In other habitats they are occasional. The third group (*M. dasycneme* and *P. kuhlii*) is similar to the later, but have obviously lower level of population and limited localization. The Pond bat is evidently common in habitats along Pripyat river and its floodplain, but not very numerous. The Kuhl's pipistrelle is absolutely synanthropic species, and was found only in vicinity of Pripyat town, ChNPP and Chernobyl town. At last, the forth group – species which were caught only once regardless their real (still unknown) abundance and distribution (*B.barbastellus*, *M.brandtii*, *M.mystacinus*, *N.lasiopterus*). Besides these four species at least one more (*Eptesicus nilssonii*) theoretically can be found in the region, it is known in neighbour regions. We do not exclude that

all these "rare" species are so because of their ecological and biological features. Our approaches to the mist-netting are not very appropriate to catch ("discover") them.

Sites where the bats were caught are shown on figures 2-11.

Table 5. Generic description of distribution of bats captures on locations of ChEZ for whole period of studies (2004-2011)

Location	Species (total number of individuals caught per location)**														Species per location
	Bb	Mb	Mm	Nla	Mds	Pk	Mdb	Es	Pa	Vm	Ppy	Nle	Pn	Nn	
Northern group of locations															
B.Soroka*					2		2				9	2	13	17	**6**
Gorodische*	1						7	1	16	5	5	53	1	166	**9**
Central group of locations															
NSHP For.								2	13			12	7		**4**
Zimovische*					1					42	9		16	2	**5**
Azbuchin								7		9	1		13	1	**5**
Cooling pond					1	1				2		1	71		**5**
Red Forest														5	**1**
ChNPP						3									**1**
Pripyat						6	7	9	2	6	20		53	1	**8**
Izumrudnoe											7		11	20	**3**
Southern group of locations															
Novosyolki*							4		1	2	3	3	2	17	**7**
Ilovnitsa							2	11	2	3	143	8	15	57	**8**
Andreevka*										1	1	1		4	**4**
Western group of locations															
Denisovichy									4	5		4		11	**4**
Akulino Galo			1							9	2	12	1	56	**6**
Vilcha*		1					1	1	5	5	11	6	3	59	**9**
Yakovetskoe For.*				1				2	6	48	19	93	5	408	**8**
Tolsty Les							8		10	1	38	62	10	102	**7**
Rechitskoe For.										1		2	1	4	**4**
Bovische											6	8	4	24	**4**
Gorodchan*							1		2			4	5	31	**5**
Krasno								1		1			5	1	**4**
Chernobyl						1		23	1		38	1	238	3	**7**
Yampol*															
Otashev													1		**1**
R.Ilinetskaya											1			2	**2**
Locations per species	1	1	1	1	3	4	8	9	11	15	16	16	20	21	

Note: *RSG-project locations. ** Bb - Barbastella barbastellus; Es - Eptesicus serotinus; Mb - Myotis brandtii; Mds - Myotis dasycneme; Mdb - Myotis daubentonii; Mm - Myotis mistacinus; Nla - Nyctalus lasiopterus; Nle - Nyctalus leisleri; Nn - Nyctalus noctula; Pk - Pipistrellus kuhlii; Pn - Pipistrellus nathusii; Ppy - Pipistrellus pygmaeus; Pa - Plecotus auritus; Vm - Vespertilio murinus.

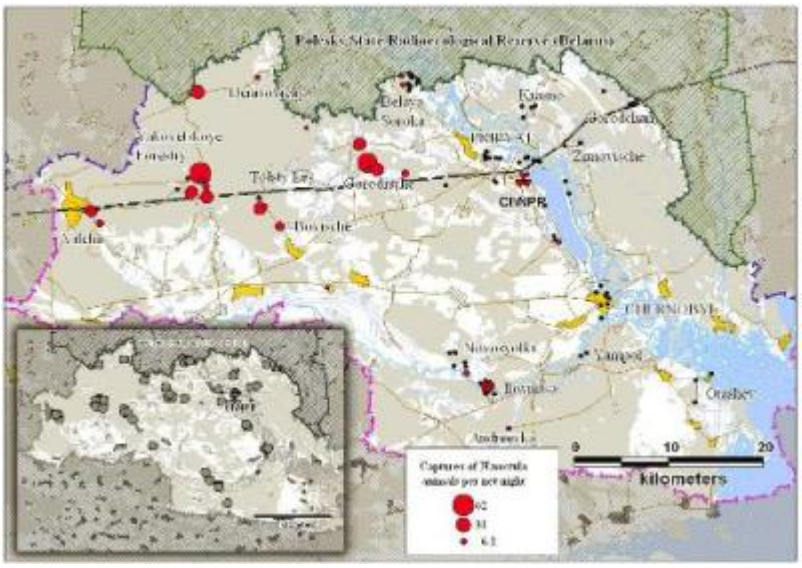

Fig. 2. Relative abundance of *Nyctalus noctula* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

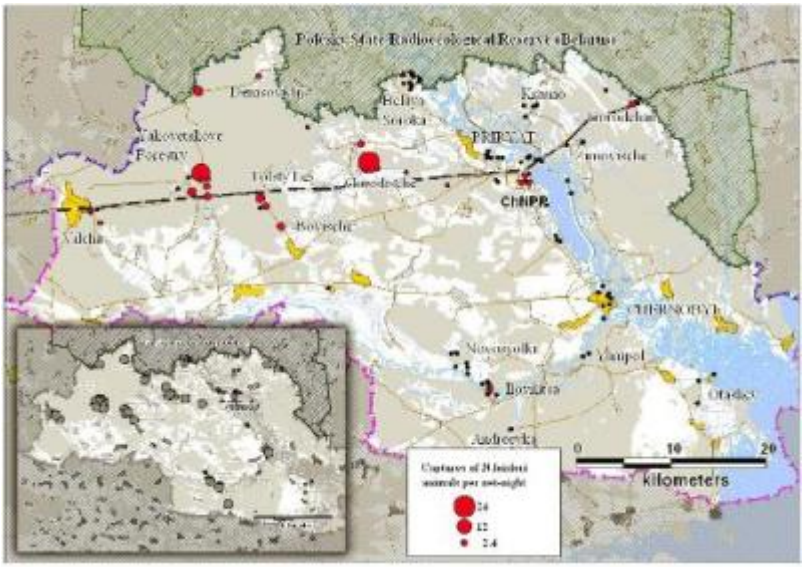

Fig. 3. Relative abundance of *Nyctalus leisleri* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

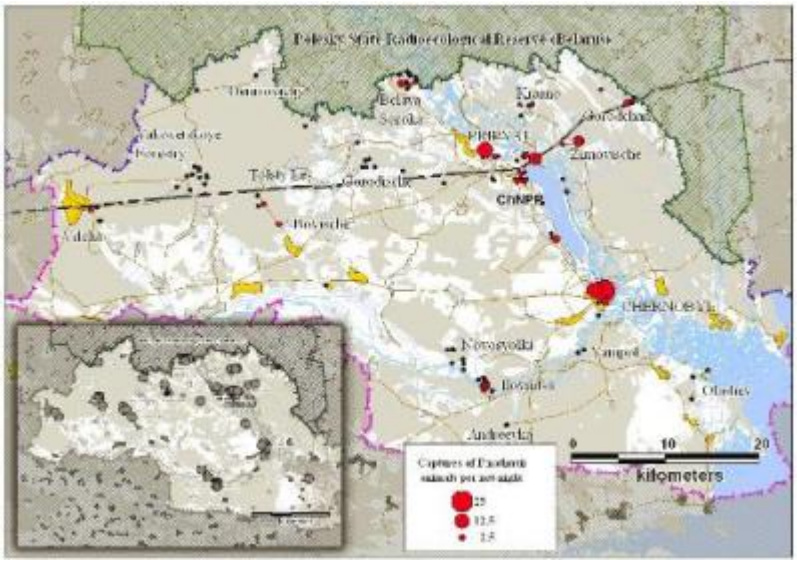

Fig. 4. Relative abundance of *Pipistrellus nathusii* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

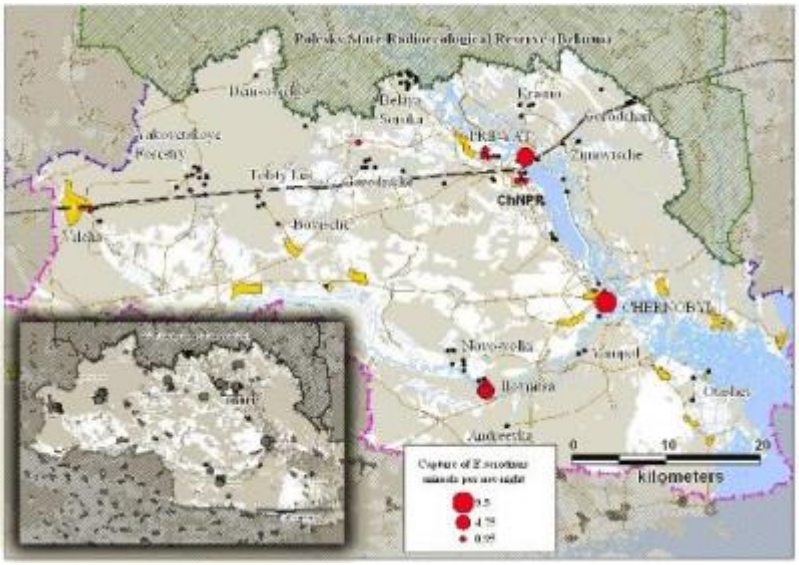

Fig. 5. Relative abundance of *Eptesicus serotinus* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

International Radioecology Laboratory of Chernobyl Center for Nuclear Safety, Radioactive Waste and Radioecology.
P.O.Box 151, 7/1, 77th Gvardiiskoi Dyvizii str., Slavutych, Kiev region, Ukraine 07100
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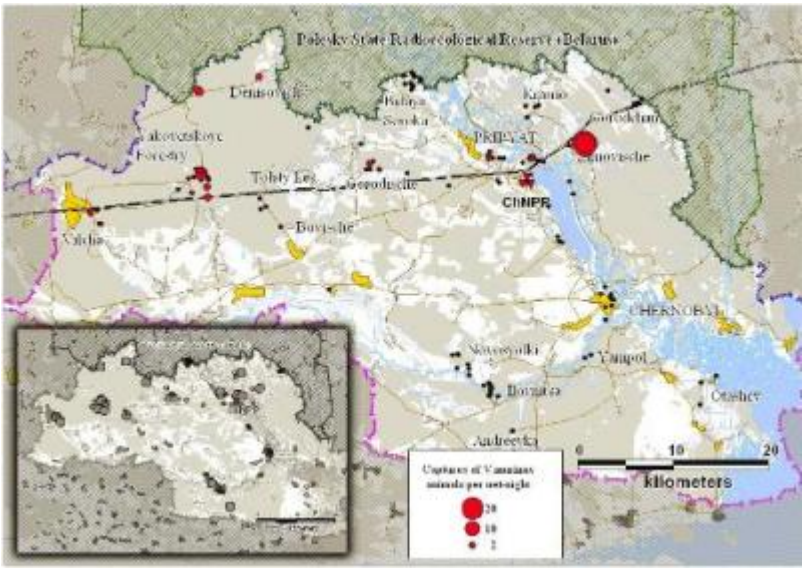

Fig. 6. Relative abundance of *Vespertilio murinus* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

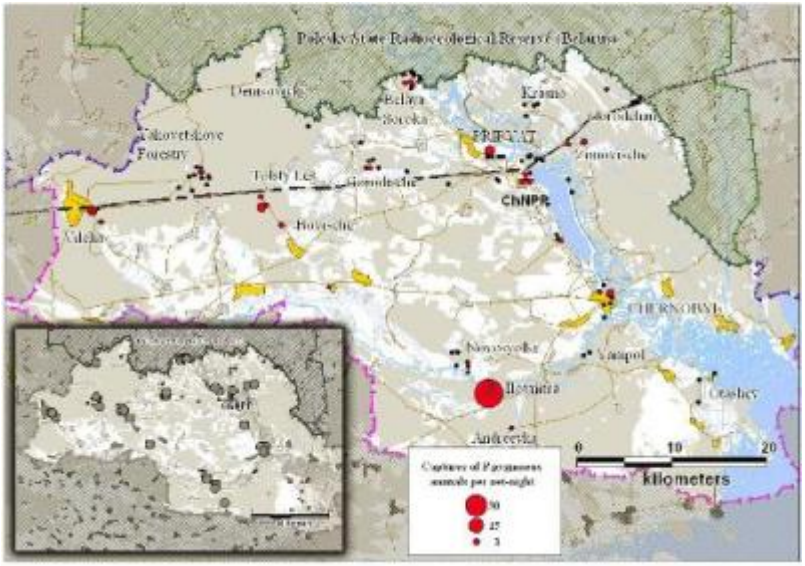

Fig. 7. Relative abundance of *Pipistrellus pygmaeus* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

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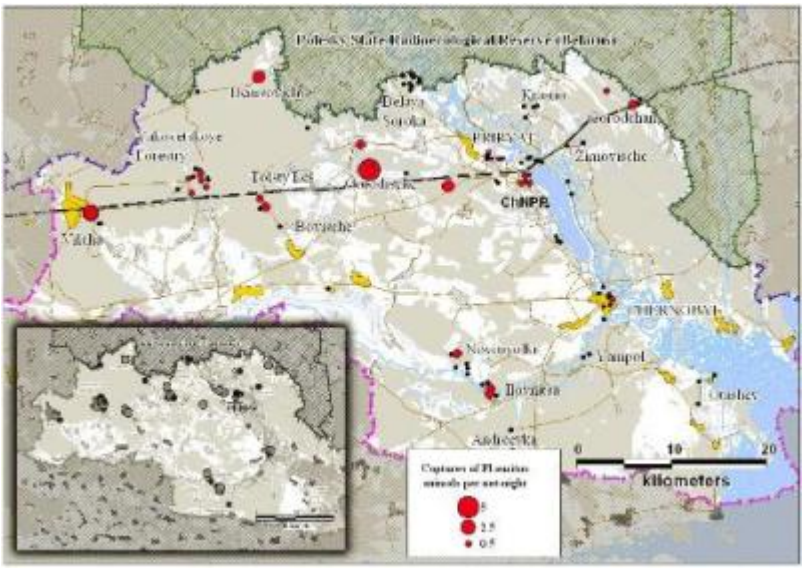

Fig. 8. Relative abundance of *Plecotus auritus* in 2007-2011 (average number of animals per net-night), hereafter the internal map – sites where the species was caught.

Fig. 9. Sites of capture of *Pipistrellus kuhlii* (2004-2011)

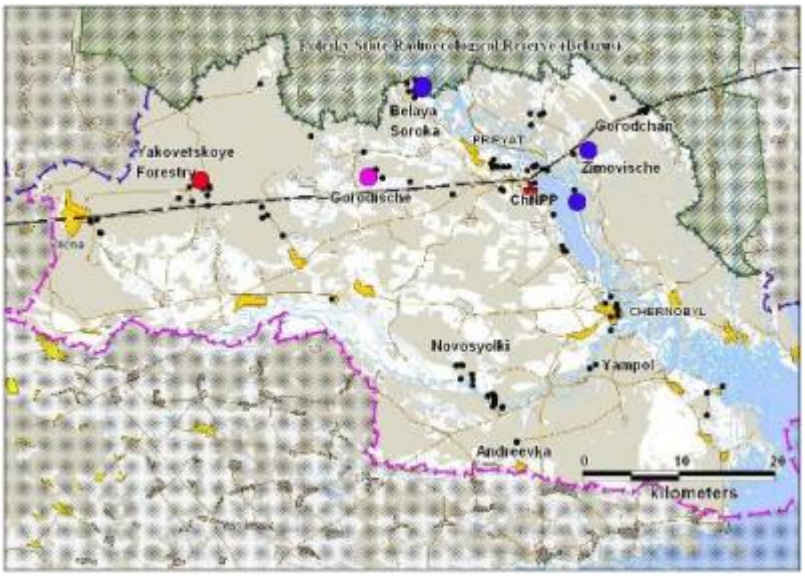

Fig. 10. Sites of capture of *Nyctalus lasiopterus* (red), *Barbastella barbastellus* (magenta), *Myotis dasycneme* (blue) (2004-2011)

Fig. 11. Sites of capture of *Myotis brandtii* (red), *Myotis mistacinus* (yellow), *Myotis daubentonii* (cyan) (2004-2011)

Worthy to note that among all species found in ChEZ there are three ones which have a high protection status in Europe – NT (IUCN 2009): *Barbastella barbastellus*, *Nyctalus lasiopterus* and *Myotis dasycneme*. Barbastelle bat was an adult female, Greater Noctule – an immature male, and Pond bat – all adult males. Thus in respect of the first two species a possible breeding in ChEZ can be supposed.

Analysis of spatial pattern of bat distribution based only on finding in certain sites (locations) provides limited imagination about preferences of different species. Value of abundance can be very useful in this respect. The data obtained in our studies can provide only relative abundance via estimation of number of bats caught during a night in one net. The estimated values of the relative abundance show that the most populated with bats regions are in W and NW parts of the ChEZ (Table 6).

Table 6. Relative abundance of bats in the ChEZ for whole period of studies (2004-2011), animals per net-night

Location	Total net-nights	Species (total number of individuals caught per location)**														
		Bb	Mb	Mm	Nla	Mds	Pk	Mdb	Es	Pa	Vm	Ppy	Nle	Pn	Nn	Species (animals per net-night)**
		Northern group of locations														
B.Soroka*	23					0.087		0.09				0.39	0.09	0.57	0.74	**2.0**
Gorodische*	10	0.100						0.70	0.10	1.60	0.50	0.50	3.70	0.10	16.60	**23.9**
		Central group of locations														
NSHP For.	12								0.17	1.08			1.00	0.58		2.8
Zimovische*	4					0.250					10.50	2.25		4.00	0.50	17.5
Azbuchin	6								1.17		1.50	0.17		1.67	0.17	4.7
Cooling pond	26					0.038	0.038				0.08		0.04	2.73		2.9
Red Forest	2															
Pripyat	13						0.462	0.54	0.62	0.15	0.46	1.54		3.92	0.08	7.8
Izumrudnoe	4											1.75		2.75	3.00	7.5
		Southern group of locations														
Novosyolki*	8							0.50		0.13	0.25	0.38	0.38	0.25	2.13	**4.0**
Ilovnitsa	19							0.11	0.58	0.11	0.16	7.53	0.42	0.79	3.00	**12.7**
Andreevka*	3										0.33	0.33	0.33		1.33	**2.3**
		Western group of locations														
Denisovichy	2									2.00	2.50		2.00		5.50	**12.0**
Akulino Galo	2			0.500							4.50	1.00	6.00	0.50	28.00	**40.5**
Vilcha*	8		0.125					0.13	0.13	0.63	0.63	1.38	0.75	0.38	7.38	**11.5**
Yakovetskoe For.*	26				0.038				0.08	0.23	1.85	0.73	3.58	0.19	14.58	**21.3**
Tolsty Les	15							0.53		0.67	0.07	2.53	4.13	0.67	6.40	**15.0**
Rechitskoe For.	2										0.50		1.00	0.50	2.00	**4.0**
Bovische	2											3.00	4.00	2.00	12.00	**21.0**
Gorodchan*	8							0.13		0.25			0.50	0.63	3.88	**5.4**
Krasno	10								0.10		0.10			0.50	0.10	**0.8**
Chernobyl	21						0.048		1.10	0.05			0.05	11.33	0.14	**14.5**
Yampol*	3															
Otashev	5													0.20		**0.2**
R.Ilinetskaya	1														2.00	**3.0**
Locations per species	235	0.004	0.004	0.004	0.004	0.017	0.034	0.14	0.24	0.26	0.60	1.33	1.09	2.00	4.01	9.7

Note: * and ** - same as in table 5.

As usual it exceeds 10 animals per net-night. Worthy to mention that just there the rare species as *Nyctalus lasiopterus*, *Myotis brandtii*, *Myotis mistacinus* were found. Other rare species, *Myotis dasycneme* and *Barbastella barbastellus* were caught also at locations with relatively high abundance of bats (Gorodische, Zimovische). A remark: *B. barbastellus* was found in the past (1950s) also in the western part of the region, near the settlement Vilcha.

However if to consider separately the relative abundance of each species a specific pattern of distribution can be revealed. Such species as *Nyctalus noctula* and *Nyctalus leislerii* definitely are more abundant in W and NW parts of ChEZ, although they were recorded almost everywhere (Fig. 2 and 3.). The similar overall very common *Pipistrellus nathusii* has higher level of population along Pripyat river floodplain (Fig. 4). Serotine bat is the most abundant near large settlements and industrial areas (Pripyat, ChNPP, Chernobyl), although can be caught even inside vast woodlands (Fig. 5). *Vespertilio murinus* appears to be mostly in northern part of ChEZ, although such suggestion can be just a result of lack of investigations (Fig. 6). Two species *Pipistrellus pygmaeus* and *Plecotus auritus* have relatively even distribution within the ChEZ, occasional large captures were connected with presence of their colonies near the mist-nets (Fig. 7 and 8, respectively).

Thus, preliminary, not all sites (locations) investigated in the ChEZ look as attractive (favourable) for all species. Among the possible reasons of this we see difference of the habitats quality. Woodlands in the western and north-west parts have plenty of plots with very old (100-200

years) deciduous and mixed forest (oak, hornbeam, aspen, ash, lime, Scottish pine). There are a lot of trees with dry trunks or branches, peeled off bark, numerous holes, etc. which can serve for bats as roosts. Such woods spread on vast territory (up to 400 km2). Besides the rich choice of roosts there are large number of hunting habitats: swamped forest, wet meadows, bogs, small rivers, lakes, forest clearings and edges.

The similar woodlands are near Novosyolky location, Ilovnitsa, Gorodische, Belaya Soroka, and in a vast region of eastern part of ChEZ where we have not worked yet.

On our observations these regions of the zone are also favourable for other rare and endangered species. We recorded there: *Lynx lynx*, *Lutra lutra*, *Sicista betulina*, *Mustela erminea*, *Bubo bubo*, *Glaucidium passerinum*, *Ciconia nigra*, *Grus grus*, *Aquila pomarina*, *Circaetus gallicus*, *Coronella austriaca*. As usual there are a lot of evidences of activity of such animals as: wild boar, elk, red deer, roe deer, beaver, wolf and others.

In some central parts of the ChEZ and along the Pripyat river floodplain the bats population appeared to be less abundant and diverse. However there are no enough grounds to state about it as a definite regularity. It can be just a result of lack of investigations and coincidence of previous studies with not very favourable seasons and weather conditions. Now, we can state only that synanthropic species (*Eptesicus serotinus* and *Pipistrellus kuhlii*) mostly inhabit these regions, as there are large settlements there; and "water" species – *Myotis daubentonii* and *Myotis dasycneme*. On our observation local wood vegetation indeed provides poorer choice of roosts in comparison with the forests mentioned above, however the bats can find there a lot of roosts in artificial constructions. Perhaps this is just a point of species ecological flexibility.

Regardless the bat population in the central part of the ChEZ and along the Pripyat river floodplain some these territories have undoubtedly high nature value. These are areas where a lot of birds (waterfowl, white tailed eagle, herons, sterns, sandpipers, etc) concentrate; these are habitats of otter, ermine, beaver, and all ungulates and wolves. In many locations of the floodplain number of orchid plants can be found. Also, according to published data diversity of fishes in the Pripyat river is remarkably higher than in Kievsky reservoir where the river outfalls.

Conclusions

Thus, on the base of data obtained in RSG project and earlier the following conclusions can be made:

1. Fauna of bats in the ChEZ is represented by almost all possible for this geographic region species (14 of 16-17). Most of species (11 of 14) breed in the region.
2. Three species - *Barbastella barbastellus*, *Nyctalus lasiopterus* and *Myotis dasycneme* - have a high protection status in Europe – NT (IUCN 2009).
3. The highest relative abundance and species diversity of bats coincides with areas of old (100-200 years) deciduous and mixed forests, mostly in western and north-west areas of the ChEZ, around settlements Vilcha, Yakovetskoye Forestry, Denisovichy, Tolsty Les, Bovische. The relatively high abundance of bats was noted in similar habitats of the locations Gorodische, Novosyolki and Ilovnitsa.
4. The mentioned above locations are notable also with large diversity of other group of animals and plants, including endangered ones.
5. All these territories are worthy high protection status (establishment of protected areas of high category) in the first order. Scheme of the territories localization is shown on Figure 12.
6. Areas on the north and centre of the ChEZ, along the Pripyat river floodplain and in eastern part of the region need additional investigations. Relative abundance of bats is not very high there, however it is high enough in some sites, and one endangered species – *Myotis dasycneme* (NT: IUCN 2009) – was several times recorded only there. These habitats are also very valuable for other biota.

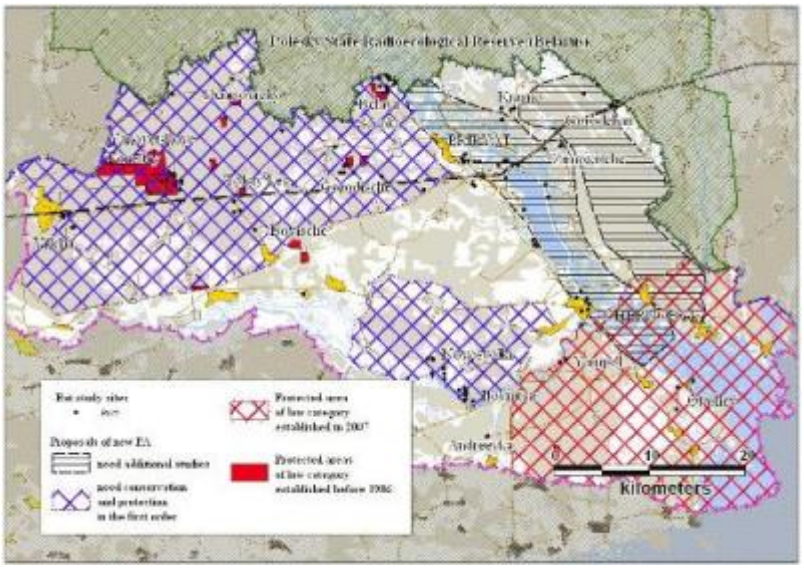

Fig. 12. Scheme of location of the prospective protected areas of high categories proposed on the base of results of RSG project.

Other kinds of activity in framework of the RSG project

Participation in the conference

In August 2010 the principal investigator of the RSG project – Sergij Gashchak – took part in the work of 15th International Bat Research Congress held in Prague, Czech Republic. Two reports where presented:

1. Oral. Bat fauna in Chernobyl Exclusion Zone (co-authors: Vlaschenko A., Naglov A., Beresford N.A.).
2. Poster. ^{90}Sr and ^{137}Cs activity concentrations in bats in the Chernobyl exclusion zone (co-authors: Beresford N.A., Maksimenko A., Vlaschenko A.).

In the first one information about bats diversity, distribution, population state and status in the ChEZ were reported. There was explained why we study the bats in Chernobyl, why it is important. Information about endangered species were told specifically. Generic description of natural and ecological conditions and modern state of flora and fauna of the ChEZ as a whole was given as well. An idea to establish protected areas of high category in the ChEZ was claimed and grounded.

Participation in the conference was taken mostly due to sources unrelated with RSG budget, however beginning of the RSG project allowed to pay off additional expenses during the conference.

Support by Ministry of Emergency of Ukraine

Though the International radioecology laboratory has never been supported by budget of the Government of Ukraine, long-term efforts to get such support at last gave a result. The data obtained during RSG project were also very important and used for the justification of the funding.

Since July 2011 Ministry of Emergency of Ukraine (which is responsible for all kinds of activity in the ChEZ) allocated finance for a theme: “Definition of the exclusion zone’s areas with highest index of biodiversity as an indicator of ecological equilibrium and radioecological

stability". In fact the final aim is the same as in RSG project: justification of necessity to increase protection category of the Chernobyl lands as valuable natural complexes and to develop environmental and conservation activity there.

During a year we also prepared an application in the Ministry of Emergency about support of activity on making up ecological passports of the most valuable in environmental concern areas as an obligatory component of any proposals of protected areas. At success it is supposed to carry out in 2012-2014 years.

Application for Global Ecological Fund

Since April 2011 (after the next anniversary of the Chernobyl tragedy) the International radioecology laboratory began a collaboration with Ministry of ecology and natural resources of Ukraine to prepare an application in the Global Ecological Fund GEF): "Enhancing of Effectiveness of Nature Protection and Sustainable Development in The Chernobyl Exclusion Zone through the Establishment of a Research and Environmental Protection Centre and Protected Area".

The point is that though there are some formal obstacles and unfavourable circumstances for the soon establishment of protected areas of high category in the ChEZ, value of local natural complexes, its biodiversity and importance in continental scale demand immediate increase of their protection level and profile (environmental) research activity. There are number international conventions ratified by Ukraine and national lows which define ways and methods of nature conservation activity even in cases when direct establishment of protected areas of high category is impossible. So, in the ChEZ there are still no organizations responsible for management of protected areas and environmental activity, and future of the most valuable lands in this concern is still not officially defined. The goal of the project applied in GEF – 1) create such organization, 2) define the most valuable areas in ChEZ, elaborate and implement a system of environmental activity in its concern, 3) undertake steps on establishment in the ChEZ protected areas of high category, 4) public relation activity in Chernobyl environment concern.

A preliminary and generic support of the project idea as a whole was received from GEF. By the reporting time the application was submitted in the GEF for consideration.

Publication

During the RSG project period we prepared an article of bats in the ChEZ:

Vlaschenko A., Gashchak S., Gukasova A., Naglov A. (2010) New record and current status of Nyctalus lasiopterus in Ukraine (Chiroptera: Vespertilionidae). Lynx, n. s. (Praha), 41: 209–216.

Though it is based on data collected earlier the issue of the article is an important contribution into justification of necessity of high protection category areas in the ChEZ.

Public relation activity

During the project period we did not have a chance to present the results of the study for the wide circle of public and scientific communities (but the participation in Prague congress 15th IBRC). There were only preliminary discussions with new potential partners of future studies, and we got principal agreement from administrators of web-sites (http://kazhan.org.ua, Ukrainian Centre for Bat Protection, and http://chornobyl.in.ua) to place the information about the project there. Since the field part of the project have been finished, and after processing of the data obtained, we will prepare proposals of the most valuable natural territories in the ChEZ, and 1) submit it in Ministry of ecology and natural resources of Ukraine, 2) present it at meeting, conferences and in public and scientific publications.

Also we were asked by a public organization from U.K. (www.WildVenture.co.uk) about possibility for volunteers to participate in our RSG studies. Unfortunately we had to decline such

proposal since 1) do not have capabilities to arrange hosting and research activity with large groups of people, and 2) did not have reliable time-schedule of the project (some our decisions were made almost in the last moment).

Finance report

We requested in RSG Foundation 5,981.55 GBP. The initial finance plans supposed expenses reflected in the table 7:

Item	Amount	Price/ expenses	Currency	Rate	Total in GBP
Equipment					
Bat ultrasonic detector Pettersson D240x	1 unit	10500	SEK	0.0846	888.30
Software BatSound v.4	1 unit	4000	SEK	0.0846	338.40
Borescope DCS400	1 unit	300	USD	0.6154	184.62
Headlight Petzl Tactikka Plus E49P	2 units	890	UAH	0.0763	67.91
Climbing rope (10mm)	60 m	1300	UAH	0.0763	99.19
Consumables & Service					
Batteries	total	800	UAH	0.0763	61.04
Fuel for the car: 0.13 L/km, 8000 km, 1 USD/L	total	1040	USD	0.6154	640.02
Repair of the car (just in case)*	total	5000	UAH	0.0763	381.50
Field Work & Travel					
Journeys of the project team from Kharkov to Chernobyl, both ways (4 journeys x 4 persons x 200 UAH).	total	3200	UAH	0.0763	244.16
Daily expenses of the Kharkov team (3-4 persons) during the field works in Chernobyl (168 person-days x 140 UAH)	total	23520	UAH	0.0763	1794.58
Daily expenses of other participants (2-3 persons) during field works in Chernobyl (120 person-days x 140 UAH)	total	16800	UAH	0.0763	1281.84
TOTAL					5981.55

* We charged (reserved) some money for repair of the car is intensively used in off-road conditions (this item of the expenses was based on our previous experience)

RSG Foundation awarded the project with 5,982.00 GBP. Since my personal account was for USA dollars, and because of actual exchange rate (GBP/USD) and value of fee for the bank transaction (both are unknown for me), near 8,805.00 USD were received (26.06.2010). At that date the exchange rate GBP/USD (on http://finance.yahoo.com) was 1.5065. The later value was used to recalculate the project expenses in British Pounds.

The real expenses during the project are in the table 8.

We purchased the Pettersson bat-detector and software on price of tax-free, and without shipping expenses, since bought it during the 15th IBRC congress in Prague. It saved money. Also, total number of days spent for field work, number of participants and average daily expenses were also less than the supposed. These circumstances allowed to revise the initial budget, and to purchase additional equipment necessary for the filed bat studies: rechargeable batteries for different gadgets (GPS, detector, digital recorder, headlights), and equipment to charge it in field conditions (solar panel with universal battery pack, controller and charger). Also we bought chiropterological rings.

Table 8. RSG-project's expenses

Item	Units	N	Cost per unit		Total expenses		Rate UAH/ USD	Total expenses	
			UAH	USD	UAH	USD		USD	GBP
Fee for the bank service (2% of total amount,)	total	1	1391.75		1391.75		0.1265	176.10	116.89
Headlight Petzl Tikka 2	Units	1	287.00		287.00		0.1265	36.31	24.10
Headlight Petzl Tikka Plus 2	Units	1	450.00		450.00		0.1254	56.43	37.46
Bat ultrasonic detector Pettersson D240x + Software BatSound v.4	Units	1		1420.00		1420.00		1420.00	942.58
Solar panel Sunlinq 25W + shipping	Units	1		324.39		324.39		324.39	215.33
Universal battery pack Tekkeon myPower All Plus 3450	Units	1		139.95		139.95		139.95	92.90
Sunlinq 7Amp Solar Panel Charge Controller	Units	1		43.95		43.95		43.95	29.17
Tenergy BC1HU fast smart battery charger	Units	1		39.95		39.95		39.95	26.52
Boroscope DCS400 + shipping	Units	1		313.37		313.37		313.37	209.01
Chiropterological rings (Aranea, Poland), 2500 rings	total	1		600.00		600.00		600.00	398.27
Rechargeable batteries: AA	Units	8	26.00		208.00		0.1253	26.06	17.30
Rechargeable batteries: AAA	Units	8	32.00		256.00		0.1253	32.08	21.29
Rechargeable batteries: 9V	Units	2	95.00		190.00		0.1253	23.81	15.80
Consumables (miscellaneous)	total	1	964.20		964.20		0.1254	120.91	80.26
Travel expenses (Jul 2010)	person	4	200.00		800.00		0.1267	101.36	67.28
Travel expenses (May 2011)	person	4	200.00		800.00		0.1254	100.32	66.59
Travel expenses (Jul 2011)	person	4	255.00		1020.00		0.1255	128.01	84.97
Daily expenses during field work (Jul 2010) (19 d x 5 persons)	person-day	95	130.00		12350.00		0.1267	1564.75	1038.66
Daily expenses during field work (May 2011) (11 d x 5 persons)	person-day	55	135.00		7425.00		0.1254	931.10	618.05
Daily expenses during field work (Jul 2011) (14 d x 5 persons)	person	70	135.00		9450.00		0.1255	1185.98	787.24
Daily expenses during scout & bat detection trips	person	10	126.00		1260.00		0.1260	158.76	105.38
Fuel	1	75.15	6.95		522.30		0.1266	66.12	43.89
Fuel	1	51.17	6.86		351.10		0.1267	44.48	29.53
Fuel	1	79.57	6.95		553.00		0.1267	70.07	46.51
Fuel	1	40.00	9.80		392.00		0.1253	49.12	32.60
Fuel	1	60.00	9.90		594.00		0.1253	74.43	49.40
Fuel	1	65.05	9.75		634.24		0.1253	79.47	52.75
Fuel	1	25.13	9.75		245.02		0.1255	30.75	20.41
Fuel	1	42.10	9.50		399.95		0.1255	50.19	33.32
Fuel	1	22.30	9.70		216.31		0.1255	27.15	18.02
Rent of a car (instead the regular one broken in Jul 2011, 14 d)	total	1.00	2300.00		2300.00		0.1255	288.65	191.60
Repair of the car	total	1.00	2000.00		2000.00		0.1255	251.00	166.61
Travel expenses during 15th IBRC, Aug 2010 (Prague, Czech Republic)	total	1.00		250.00		250.00		250.00	165.95
TOTAL								8805.00	5844.67

Note: N – total amount of units; UAH – Ukrainian Hryvnia; USD – dollar of USD; GBP – British pound; "Rate UAH/ USD" – in day when the expenses took place.

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